



COSTS ASSOCIATED WITH THE  
PROTECTION OF THE UNITED STATES AGAINST SMALLPOX<sup>a</sup>

by

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SUMMARY

The cost of protecting the United States civilian population against smallpox is estimated to have been \$ 154 million in 1968. These costs were largely those of the act of vaccination, including time lost from work, physician fees, and costs for treatment of vaccination complications. The United States' share in the global smallpox eradication programme was less than 3% of the total expenditures for smallpox protection. The recent change in vaccination policy for the United States which deemphasizes routine smallpox vaccination has a sound economic as well as medical basis.

INTRODUCTION

The smallpox endemic area is shrinking rapidly throughout the world. The number of countries reporting smallpox has decreased from 91 in 1945, through 42 in 1967, 30 in 1969, 23 in 1970, and 17 in 1971 - the 175th year since the first vaccination against smallpox by Jenner.<sup>1</sup> The eight nations where smallpox is now endemic are directing efforts toward the eradication of the disease with the leadership of the World Health Organization. The global strategy for the eradication of smallpox is based on the fact that no non-human reservoir exists for smallpox, and therefore smallpox will cease to exist altogether once the last human case had occurred. The threat of smallpox importation from areas where a reservoir remains has led smallpox-free countries to continue smallpox protection programmes. The rapidly declining number of countries with smallpox has directed attention to the continuing policy of routine vaccination of the population, with its recognized risks of complications.

This paper will briefly review the epidemiologic data with respect to routine vaccinations, the risk of untoward complications of vaccination, and the estimated cost of the effort to protect the civilian population in the United States in 1968. Major cost estimates include those for medical services associated with vaccinations, medical care for complications of vaccinations, governmental protection services, and governmental support for international disease eradication. The latter is included in this analysis since public health officials must face the question: "What is the most rational distribution of our Nation's resources between domestic protection and international disease eradication?" The problem is complicated because the benefits associated with the domestic protection policy are influenced by

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support for and success of international disease eradication. In deciding upon a strategy of protection from smallpox, total benefits and costs of both the domestic protection effort and the international smallpox eradication programme must be considered, recognizing that the benefits are interdependent.

### Vaccinations

Detailed data on smallpox vaccinations in the United States were obtained in the National Immunization Survey in September 1968. This survey is an annual supplement to the Census Bureau's Current Population Survey. The probability sample for estimates of immunization levels involves 35 000 households or approximately 100 000 persons. In 1968, the survey estimated that 14.2 million persons in the civilian population were vaccinated; 5.6 million received a primary vaccination, and 8.6 million were revaccinated. Table 1 presents the smallpox vaccinations by age group and population coverage. Overall, 21.4% of the children one to four years of age and 15.3% of the persons in the age category five to nine years were vaccinated in 1968.<sup>2</sup>

### Complications

Because there is no national system for reporting complications of smallpox vaccinations, a series of special studies of these conditions were conducted in 1968. The more serious vaccination complications were detected through the distribution system for vaccinia immune globulin. This information was supplemented by in-depth surveys in several states, analysis of death certificates, and a variety of other sources.<sup>3,4</sup> Table 2 presents the estimates of the complications based on these surveys.<sup>5</sup> Overall, 8024 complications were estimated or a rate of 566.3 per one million vaccinations. The 153 major complications represent a rate of 10.8 per one million vaccinations. Of the 153 cases, 16 cases were diagnosed post-vaccinial encephalitis, 11 cases vaccinia necrosum, and 126 cases eczema vaccinatum.<sup>3</sup> Overall, 3.0% of the 8024 cases were hospitalized for an average of nine days and a total of 2142 patient-days of hospitalization. Of the 16 patients with post-vaccinial encephalitis, three have permanent mental damage, including one requiring institutionalization for life. Nine vaccine-associated deaths occurred in 1968: four following post-vaccinial encephalitis, four associated with vaccinia necrosum, and one associated with eczema vaccinatum.

### Methodology

In economic terminology, costs include two components. The first is the direct cost of the resources used to protect the United States against smallpox. The second is the indirect cost resulting from the loss of individual productivity of persons who cannot work, or cease to be productive because of premature death. Direct costs estimated in this analysis include actual outlays made by individuals, industry, and governmental agencies to protect the United States against smallpox. Indirect costs represent the value of output lost measured by estimating wages lost for time off work and by earnings foregone because of disability and death.

The method used to estimate these losses is similar to that used by Rice.<sup>6</sup> For disability and mortality losses, estimated future earnings are discounted to determine the present value of the earnings in 1968. Money invested at "X" rate of interest will increase in value over time. For example, \$ 100 invested today at 6% interest will amount to \$ 106 one year from today. The sum \$ 100 is called the present value of \$ 106 one year in the future if money is worth 6% per annum. The \$ 106 is discounted or rolled back in time at 6% to determine the present value.

### Physician and hospital services

Physician services associated with vaccination comprise the principle cost. Physician charges for office visits are based on data from the Consumer Price Index in 1962.<sup>7</sup> We adjusted these figures by the Bureau of Labor Statistics Physician Fee Index to reflect the

cost in 1968.<sup>8</sup> In 1968, the average charge for an office visit was \$ 6.55. This estimate is consistent with an American Medical Association study which reported average fees for an initial office visit of \$ 7.83 for general practice in 1969.<sup>9</sup> The physician charge for vaccination services is based on relative value studies and includes both vaccination and reading of the vaccination.<sup>10</sup> Clinic costs for vaccination were assumed to be equivalent to private physician costs. We further assumed that the cost of the vaccine was included in the physician office visit or clinic charge. We calculated the vaccine price separately to illustrate its nominal cost. The vaccine cost per dose ranged from \$ .15 in single dose packages to \$ .04 in multiple dose vials to private physicians and public agencies.

Estimates for physicians' charges to patients with complications of vaccination are based on the assumption that the typical patient had an office visit necessitating complete re-examination and re-evaluation of a patient, and one follow-up office visit. Where the patient was hospitalized, he is assumed to have had a complete diagnostic history and examination, daily visits during the hospital stay, and one follow-up office visit following hospitalization.

During 1968, the physician charge for the initial office examination was \$ 19.65 and for each follow-up office visit \$ 5.24. For hospitalized patients, the charge for the hospital examination was \$ 39.30 and for each follow-up visit \$ 6.55. Hospital expense estimates are based on the average daily charge for short-stay community hospitals. The 1968 daily estimate was \$ 61.38.<sup>11</sup>

#### Other direct costs

The cost of long-term care for the child who was institutionalized was estimated at \$ 3000 per year per child over the normal maintenance cost.<sup>12</sup> This cost is assumed to occur each year for 40 years. The present value of the cost in 1968 was \$ 45 000 at a discount rate of 6%.

The cost of drugs used and purchased outside the hospital for the 7786 patients was based on the average retail cost for anti-infective and anti-allergic prescriptions of \$ 4.89 in 1968.<sup>13</sup> The cost of vaccinia immune globulin is taken from the government budget for the procurement and emergency distribution.

The cost to American travellers for official international certificates of vaccination was estimated at \$ .26 per certificate for two million certificates.

The cost of governmental services to protect the nation against smallpox includes federal, state and local governmental expenditures for air and sea vessel clearance and for surveillance. We also estimated the cost of time lost by the maritime industry in waiting for clearance of 40 000 sea vessels. In 1968 the Port of New York Authority estimated the cost of quarantine vessel clearance to the shipping industry as \$ 200 per vessel.<sup>14</sup>

A final part of the direct costs includes the cost of the multilateral support to the World Health Organization for the smallpox eradication programme and bilateral support to the smallpox eradication campaign in 20 countries in West Africa.<sup>15,16,17</sup>

#### Productivity losses

The indirect economic cost is comprised of current and future earnings foregone. The value of time lost from work because of travel vaccination requirements and complications of vaccination was estimated separately for six age and sex groupings, assuming the mean earnings and the labour force participation for the general population. The future losses as a result of premature death, or of mental retardation disability, take into account factors such as the distribution of morbidity or mortality by different age and sex groupings, labour force participation rates, earnings, and life expectancy. The lifetime earning losses were discounted at 6% to maintain consistency with the methodology of other health economic analyses in the late 1960s.

### Results

Table 3 indicates that the economic cost of smallpox vaccinations among civilians in the United States totalled an estimated \$ 135.6 million in 1968. Physician services for vaccine administration accounted for 69% of this amount. Of the \$ 1.2 million for complications of vaccination, about one-fourth was for physician services.

The cost of the effort to protect United States citizens against smallpox exceeded \$ 153 million in 1968. As shown in Table 4, 85% of the cost was associated with vaccination of the civilian population.

The costs of quarantine traffic clearance and surveillance and maritime industry losses for traffic clearance accounted for 9.4% of the total cost. The United States' support to the World Health Organization's global smallpox eradication programme and the United States developmental assistance to 20 countries in West Africa for smallpox eradication totalled only 2.4%.

### DISCUSSION

The results clearly indicate that the public policy decision to discontinue routine vaccination of the general population and smallpox vaccination requirements for international travel to smallpox-free countries released substantial medical and economic resources for other uses. This analysis indicates the costliness of an internationally important and emotionally fearful infectious disease in a country where the disease has not occurred since 1949. It also suggests that the magnitude of global benefits of the forthcoming worldwide eradication of smallpox is substantial.

The economic analysis does not consider the costs associated with a possible introduction or importation of smallpox into the United States. The several importations into Europe in recent years have not been analysed regarding costs. In 1965, a patient with chicken-pox was misdiagnosed as smallpox,<sup>18</sup> and the resultant public health control efforts, without secondary spread, cost approximately \$ 65 000. Of the total cost, 64% involved expenditures for surveillance of the primary ring of contacts, 30% for hospital isolation care, 4% for laboratory services, and 2% for communications. About 85% of the total cost involved diverted personnel time. Such costs would be incurred in the event of an importation of smallpox regardless of how much is spent on routine vaccinations or other smallpox protection efforts. Only worldwide smallpox eradication will eliminate the risk of possible importations and subsequent potentially expensive secondary-spread control efforts.

In the short run, the national protection strategy must continue the United States' support to the World Health Organization smallpox eradication programme in order to realize the full benefits of this policy change.

TABLE 1. SMALLPOX VACCINATIONS BY AGE AND VACCINATION STATUS, UNITED STATES - 1968

Age	Primary	Revaccinations	Total	% Population covered
< 1	614 000	0	614 000	17.6
1-4	2 733 000	478 000	3 211 000	21.4
5-9	1 553 000	1 643 000	3 196 000	15.3
10-19	406 000	2 657 000	3 063 000	8.1
20 +	288 000	3 796 000	4 084 000	3.4
Total	5 594 000	8 574 000	14 168 000	7.2

TABLE 2. COMPLICATIONS ASSOCIATED WITH SMALLPOX VACCINATIONS OF CIVILIAN POPULATION, BY DEGREE OF SEVERITY, UNITED STATES, 1968

Complications	Complications medically attended		Hospitalized complications		Permanent disability	Deaths
	No.	Rate*	No.	Average stay		
Post-vaccinial encephalitis	16	1.1	16	11.3	4	4
Vaccinia necrosum	11	0.8	8	37.5	-	4
Eczema vaccinatum	126	8.9	87	11.2	-	1
All other	7 871	555.5	127	5.9	-	-
Total	8 024	566.3	238	9.0	4	9

\* Complications per 1 000 000 vaccinations.

TABLE 3. ESTIMATED ECONOMIC COSTS ASSOCIATED WITH SMALLPOX VACCINATION  
FOR THE CIVILIAN POPULATION, UNITED STATES - 1968

	Amount	
<u>Direct costs</u>		\$ 93 460 000
Physician services		
Office care		
Vaccine administration	91 454 000	
Vaccine	1 346 000	
Complications of vaccination	280 000	
Hospital care		
Complications of vaccination	25 000	
Hospital services		
Complications of vaccination	132 000	
Institutional care for mentally retarded*	45 000	
Vaccinia immune globulin, drugs	78 000	
Surveillance of complications of vaccination	100 000	
<u>Indirect costs</u>		42 196 000
Earnings lost due to time off work for vaccinations and complications of vaccinations	41 705 000	
Earnings lost due to premature death as a result of complications of vaccination*	378 000	
Earnings lost due to permanent disability as a result of complications of vaccination*	113 000	
<b>Total economic cost</b>		<b>\$ 135 656 000</b>

\* Future years discounted at 6%.

TABLE 4. ESTIMATED ECONOMIC COSTS ASSOCIATED WITH PROTECTION OF  
THE UNITED STATES AGAINST SMALLPOX, 1968

	Amount
A. Costs of smallpox vaccination and complications of vaccination	\$ 135 656 000
B. 1. Costs of traffic clearance and international surveillance	6 462 000
2. Cost of time lost by maritime industry in waiting for clearance	8 000 000
C. 1. Cost of United States support to World Health Organization for smallpox programme	699 000
2. Cost of assistance to smallpox eradication efforts in 19 countries in West Africa	2 959 000
Total economic cost	\$ 153 776 000

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